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# Citizen Design Science: A strategy for crowd-creative urban design

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ABSTRACT

The last decades in urban design research are characterised by a focus on technological aspects of cities which is commonly known as the smart city strategy. The concerns and interests of citizens are coming to the forefront nowadays with the awareness that a liveable city does not only consist of good infrastructure and sustainable energy supply but also citizen input and feedback. In this paper, we present Citizen Design Science as a new strategy for cities to integrate citizens' ideas and wishes in the urban planning process. The approach is to combine the opportunity of crowdsourcing opinions and thoughts by citizens through modern information and communication technology (ICT) with active design tools. The active design feedback from a city's inhabitants is identified as a yet missing but essential way towards a responsive city. We therefore propose a system to merge Citizen Science and Citizen Design, which requires a structured evaluation process to integrate Design Science methods for urban design.

We show examples of existing approaches of Citizen Design Science and present the Quick Urban Analysis Kit (qua-kit) as an application of this methodology. The toolkit allows users to move geometries in given environments and provides the opportunity for non-experts to express their ideas for their neighbourhood or city.

## 1. Introduction and motivation

Cities around the world are facing tremendous challenges. For example, emerging cities in Asia and Africa often have to deal with unexpected side effects from mass transport, inadequate urban infrastructure, or other environmental side effects due to fast growth of urban areas and demand flexible and adaptive strategies for urban planning. The approach from the last decades was to harness innovative technologies and acquire knowledge through data mining strategies. This movement to optimise the city is known as the *smart city* concept.

There are several definitions of a smart city circulating in research. Our work invokes the standard that is based on the evaluation of several definitions by the International Telecommunication Union. They declare a smart city an "innovative city that uses information and communication technologies (ICT) and other means to improve quality of life, efficiency of urban operation and services, and competitiveness, while ensuring that it meets the needs of present and future generations with respect to economic, social and environmental aspects" (Kondepudi, 2014, p. 13). The concept of smart cities characterises the city for aspects of efficiency and effectiveness and areas of concerns like energy consumption, administration and traffic.

The problem of this consideration is that the human aspects like the perception of space are not regarded. Smart city technologies are not a panacea for cities as pointed out by Battarra, Gargiulo, Pappalardo, Boiano, and Oliva (2016). Present strategies are therefore focusing on human-centred technologies and try to engage citizens in the planning process. This transformation is sometimes labelled as Smart City 2.0 strategies (Pomeroy, 2017). We will use the formulation of the *Responsive City* in this paper, as it is proposed by Goldsmith and Crawford (2014). This term reflects the changeover from top-down governed cities towards citizen-centred and citizen-inclusive governance in the best way.

The main reason for having the vision of a responsive city for future cities is that mere smart technologies fail to integrate evolving self-organizing entities by dealing with mainly post-occupied spaces and it cannot improve aspects of cities that go beyond easily quantifiable criteria. Such aspects are for instance the quality of life, also designated as liveability, or the citizens' identification with a place.

There are many solutions to make this vision practical. We concentrate in this paper on participatory design approaches in urban planning and from here develop a new strategy which combines active co-designing with crowdsourcing methods. The difficulty is that co-creation of design is typically based on a continuous communication between the designer and the co-creators (e.g. the user of the product). By including a large amount of people in a co-design process, it is not only an issue of how the design ideas of the co-creators can be collected

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but also how the information can be transformed to useful input for the designer. The presented method is more complex than a simple add-on of the existing co-creation. We therefore give the new strategy its own name and designate it as *Citizen Design Science*.

This paper begins with a short review of the history for participatory planning and some current approaches how ICT can improve urban design and planning processes. Another focus is on community workshops which enable active designing with residents.

We present the idea of Citizen Design Science while also taking the presented challenges as basis. After the discussion of the theoretical framework, we bring it in context of existing and upcoming user-centred and participatory design. At the end, we introduce the Quick Urban Analysis Kit (qua-kit) as a design tool that enables non-experts to do simple design tasks. Due to the simple handling for the user, we see it as an appropriate, powerful enabler for Citizen Design Science.

## 2. A sketch of citizen participation and participatory design in urban planning

Before discussing the research areas which affect Citizen Design Science, we want to clarify the different terms that are used for its description.

**Citizen engagement** or more commonly, **civic engagement**, refers to Adler and Goggin (2005) to "the ways in which citizens participate in the life of a community in order to improve conditions for others or to help shape the community's future". It is a very general description and can cover several citizen activities like volunteering in social projects or participating in public debates. More specific is the term of **citizen participation** which is understood as a political strategy. Heller, Price, Riger, Reinharz, and Wandersman (1984) defined it as "a process in which individuals take part in decision making in the institutions, programs, and environments that affect them" (p. 339).

The idea of interacting with people to benefit from their ideas does not only appear as part of governance. If the opportunity of integrating people into a developing process (e.g. of a software or product) is taken into account in general, it is called **user participation**. The participation of users which concerns the appearance and handling of the product or service, ergo its design, is named **participatory design**. Closely related to that is the term of **co-operative design** or **co-design** which refers to "collective creativity as it is applied across the whole span of a design process" (Sanders & Stappers, 2008). The act of collective creativity is called **co-creation** and means the process when "creativity […] is shared by two or more people" (ibid.). These people can either be trained designers or non-experts. The expressions of **community consultation** or **community design** are in this paper interchangeably used to user participation or co-design, respectively, and emphasise that the user is seen as part of an entity with similar ideas, needs and demands. **Design Thinking** is a broad term for different strategies of collecting ideas and finding developing innovation for what is desirable, viable and feasible for the user (Stimmel, 2015, p. 51).

Another vogue characterisation of processes, products and services is **user-centred**. We will use this term in this paper according to Sanders' definition (Sanders & Stappers, 2008). The user is in this kind of design process seen as subject and does not necessarily interact with the designer. The participatory approach is opposed to this a design process where the user is considered as partner. In a user-centred approach, design researchers serve as communicator between user and designer (Sanders, 2002). They interpret the information of the user, often in form of design criteria, and the designer interprets these criteria which is typically done in the language of sketches or scenarios.

New technologies have facilitated new opportunities of involving people in the design process. The combination of crowdsourcing ideas and co-design strategies is called **distributed participatory design** or **mass-participatory design** (Lorimer, 2016).

After this sortie to general design strategies, we will focus again on urban design. As we see citizens as the user of urban design, we can transfer the terms above to urban design by replacing 'user' by 'citizen' or specifying the expressions. **Participatory planning** comprises urban planning processes with citizen participation while **citizen-centred planning** encompasses urban planning processes which primarily focus on optimising the public space for citizens but not necessarily include citizen participation methods.

To explain and embed the strategy of Citizen Design Science in the varieties of participatory planning, we give an outline of research objects and discussions in the past decades.

The first attempt to structure citizen participation was carried out by Arnstein (1969). The presented ladder of participation contains eight rungs, namely manipulation, therapy, informing, consultation, placation, partnership, delegated power and citizen control. They are seen as hierarchical, though the author does not give instructions how to ascend to the next step of participation as pointed out by Berman (2015). In his work, he adds the practical dimension by classifying participatory practice regarding to their capacities of incorporating residents' perspective and needs into planning, which he develops as the Participatory Method Ladder. The hierarchical model was criticised fiercely by Grönlund because of the two basic assumptions for this model. This criticism was namely that typically more sophisticated technologies mean better participation and more participation means better democracy, but only proves to be true with direct democracy as the ideal value (Grönlund, 2009). The hierarchy in a model for participation was much discussed in literature (Collins & Ison, 2006; Fung, 2006; Tritter & McCallum, 2006). Since the strategy of Citizen Design Science works independently from the theoretical model the participation is based on, we want to leave the topic at the mention of the corresponding literature and focus on the benefits of participatory design in urban planning.

The feedback from research for citizen participation and especially participatory design in urban planning is generally positive.

Participation strengthens the role of the citizens and therefore direct democratic decision processes. Another effect is that the participation of people in community design activities or other collective local interest groups can be identity-establishing for the citizens and therefore seen as a part of community development (Saad-Sulonen & Horelli, 2010).

However, it is not only the identification with the community that is affected by participatory processes. Smith (1983) depicted the process and goal of citizen participation as a set of procedures to consult, involve, and inform the public to allow those affected by a decision to have an input for that decision. Citizen participation could be treated as the significant strategy towards the goal to construct liveable and resilient smart urban environments. Brown and Wyckoff-Baird (1992) consider multiple levels of local community involvement for the design, implementation and evaluation of projects or plans. As long as public benefits are touched, public participation could clearly bring benefits to scientific and technology policy making. Berntzen and Johannessen (2016) highlight citizen's role in the participatory process. They state that citizens' competences and experiences can produce better plans and services, and a democratic process is usually helpful to build liveable environments.

This review shows the potential and benefits of citizen participation and especially participatory planning. Nevertheless, these approaches also face some drawbacks.

1. Participatory design is time- and cost-intensive (e.g. Hughes, Randall, & Shapiro, 1992).
2. Community design in the framework of workshops is often not entirely representative. It is crucial that public participation includes the appropriate range of interests of the people (Abers, 2000). Bryson, Quick, Slotterback, and Crosby (2013) mention that participatory processes often end up by involving the ""usual suspects", people who are easily recruited, vocal, and reasonably comfortable in public arenas".

3. Citizen participation in general may bring up problems for discussion that are explicit and observable, but not those which are tacit and latent (Sanders, 2002).

We therefore propose a strategy that handles these challenges. One option to overcome the cost-intensity and underrepresentation of participatory design workshops is by surrogating the user by social scientists and others experts in design discussions (Kensing & Blomberg, 1998). Since this technique would mean no direct participation of citizens, it is the better option to use online participation tools, also to facilitate the better representation of the participants (Lyons, Walsh, Aleman, & Robinson, 2014). This is an emerging area in practice and research. Approaches to make urban planning and governance processes more transparent are often called 'open data' or 'open-governance' and include sometimes options to engage in a dialogue with authorities and decision makers which is then declared as 'e-governance'. The power of the internet as a channel for participation and - under political aspects - deliberation of citizens was already mentioned by White in 1997 (White, 1997).

One of many examples from the last decades is the master plan of Oporto's municipality in Portugal. The city plans to establish an electronic citizen service and bring public discussions to the internet where citizen can either anonymously or as registered users comment on current city projects (Oliveira, Carvalho, & Bartola, 2004).

In the scope of the project *Smarticipate*, the cities of London, Hamburg and Rome try new ways of participation. Rome focusses on bottom-up initiatives, Hamburg on open data (also in regard of the planning process) and London engages its citizens through co-design and other participatory projects in two communities (Dambruch, Stein, & Ivanova, 2016; Vogt & Fröhlich, 2016).

In public discussions about urban design and the planning process, visualisations are important to visualise the status quo and future plans. Current visualisation tools range from simple 2D sketches and maps to 3D and virtual reality models. Billger et al. however revealed in their review of 114 articles published between 2004 and 2014 (Billger, Thuvander, & Wästberg, 2016) that there are still quite a few studies of implemented tools in real planning processes. The challenges that occurred are the integration and representation of data and the appropriate level of detail in the model. The focus of visualisation tools in city planning is currently on the representation for and discussion with citizens rather than the active design process with citizens using such tools.

A project which goes close to the direction of Citizen Design Science is the urban API project (http://urbanapi.eu/ or Khan, Ludlow, Loibl, & Soomro, 2014). One part of the project is to set up a 3D Scenario Creator which shows ongoing planning decisions virtually in the model. The model helps to better explain problems and its solutions and facilitates the discussion with stakeholders. Alternatives to the proposed decision can be shown interactively but do not allow own modifications by the users.

To tackle the third issue, we draw on a solution that is presented by Sanders (2002) which deals with a thorough examination of co-design. Sanders drew a sketch of how people can contribute in co-design based on experience as a designer and knowledge as a social scientist. The essential point of this process from the viewpoint of a designer, is the access to the experience of the user. For Sanders, people express their experience by saying, thinking, doing, using, knowing, feeling and dreaming. The first four activities reflect the explicit and observable levels of experience. Discussions, focus group interviews, questionnaires and observations ("say tools" and "do tools") can help to access this experience. For an entire and deeper understanding, it is nonetheless necessary to get at the tacit and latent level, meaning what people know, feel and dream. For this task the "make tools" are the solution. Make tools enable people to express themselves in different ways: emotional toolkits (e.g. creating collages or diaries with artefacts) emphasise features to show dreams, cognitive toolkits (e.g. creating maps, 3D models) focus on showing people's knowledge and (mis)understanding. Make tools allow people to actively create objects and are thus forced to think and express in a new and unusual way. This helps the designer access the latent and tacit level of user experience. The idea of 'Interactive Design' to access latent opportunities and needs is also proposed by Moggridge and Atkinson (2007). Especially innovative design ideas cannot be explained in words by participants.

We want to elaborate on Sanders' concept and use make tools for the participatory design process in urban planning.

Citizen Design Science will be evolved in the following section as a method to tackle all three challenges. As we have figured out, both active designing methods and mass-participatory design have great potential to create useful and appealing designs. We want to present the combination of these two approaches which can be best described as a crowd-creative urban planning strategy towards a responsive city.

## 3. The definition of Citizen Design Science

The term Citizen Design Science arises from the three pillars it is built upon. It is referred to as a) Citizen Science which means the participatory aspects and the kind of data collection, b) Citizen Design which implies active design by citizens and c) Design Science which is essential for the translation of citizens' design proposals into the design of urban designers. Each of these three areas is necessary for the strategy as it will be explained in following.

### 3.1. Citizen Science

The methods of Citizen Science are deployed for tasks which could not yet been solved in reasonable time by computers or that are too cost-intensive if they would be done by humans. One of the first Citizen Science projects is the *Christmas Bird Count* project (http://www.audubon.org/conservation/science/christmas-bird-count) that has existed for more than hundred years. The *Galaxy Zoo* (www.galaxyzoo.org) is a project in astronomy which calls people to classify galaxies regarding their appearance (Raddick et al., 2013). Computer image recognitions are too weak or too computational-intensive do this job. In its standards of Citizen Science, the ETH defines (ETH, 2015) the scope of this methodology as scientific research activities which refers to the general public engagement when "citizens actively contribute to science". Bonney et al. (2009) distinguishes between three different levels of Citizen Science. There are contributory projects which mean mostly crowdsourced data collection (Bird Count), collaborative projects that consist of data collection and data analyses by citizens (Galaxy Zoo) and co-creative projects where researchers and citizens work in most of all steps in a scientific project together. Citizen Design Science is most related to the latter field but does not necessarily needs to be embedded in a scientific project.

Architecture and urban design is an excellent field to apply Citizen Science methods because one yet unsolved task is to describe unambiguous criteria for liveability in cities. This problem is also challenging because there is no clear definition of this term and it can have different meanings for people from different regions and cultures. It is therefore scientifically relevant to apply Citizen Science methods in urban planning. In practice, it can be applied by doing mass-participatory design for the urban design context. The scientific viewpoint underlines how meaningful it is to regard these methods for better future cities. Riesch, Potter, and Davies (2013) already revealed in their work that a good combination of Citizen Science and public engagement can lead to win-win situations.

### 3.2. Citizen Design

The term of Citizen Design is not yet commonly found in literature. We use it to describe a specific kind of participatory design. By taking 'citizen' into the term, we emphasise that we refer to urban and not

general design as design object; by 'design' we describe that the way of performing the participation is designing itself. Citizen Design is thus the active designing of the urban habitat by citizens. We focus on the active design - or make-process as Sanders described it - to gain the hidden information of the citizens.

There are several projects in this field. The motivation for citizen participation can either come from citizens in the form of initiatives and movements or from the side of the government. An example of a bottom-up urbanism is the participatory design workshops which are carried out at the urban think tank "*Actions! Of the Real City*" (http://u-tt.com/teaching/fall2016elective/) elective course at ETH Zurich and runs in collaboration with *Verein Wunderkammer* (https://wunderkammer-glattpark.ch) which aims at rejuvenate public open space through activating bottom-up initiatives. The main design input was formulated by ETH design students. Citizens afterwards discussed the design proposals and were allowed to vary the designers' models by predefined instances. An inclusively planned building project of larger scale is currently developed for *Almere Oosterwold*. Citizens are allowed to design their own homes and gardens in coordination with an urban designer (Jansma, Veen, Visser, & van der Valk, 2014).

Singapore's NGO *Participate in Design* (http://participateindesign.org) purposes to engage citizens to beautify and improve their neighbourhood. The community workshops contain different approaches; one applied opportunity is to co-create neighbourhoods and streets by active designing of people (Participate in Design, 2016, pp. 194–197). An emphasis of their work is also on the education of children and young students regarding environment and sustainability and to motivate them in their creativity. Through this, their work also has social aspects. Similar projects are conducted by *Blok74* (www.blok74.org) in the Netherlands. The designers use gaming principles in their civic engagement workshops to understand and change the built environment. *Coin Street* (http://coinstreet.org) in London works not only as community project but also serves as a fabric for co-design of public spaces. The organisers want to strengthen the community feeling in this district. The organisation of *block by block* (http://blockbyblock.org) motivates citizens of communities to express their design ideas for their neighbourhood by using the game Minecraft. They tried this collaborative and competitive design approach in several cities to find the desired design changes of citizens.

### 3.3. Design Science

The additional difficulty for Citizen Science in Urban Design is that it is not clear how the input of activities through citizens' engagement can be "translated" to the language of designers and how the local knowledge from citizens can be used as contribution to experts' works in urban planning. The designers can filter the relevant information from the citizens if they interact with a community directly. When the dialogue is taken to the internet, this direct communication channel between designers and citizens is not given. It is therefore unavoidable to have a moderated design dialogue where the designers are aware from the beginning on what kind of knowledge they would like to get from the citizens. On this basis, they can choose the scale and tool which they want to enable for Citizen Design. A Citizen Design Science approach without any rules involves the danger that the participants are over-challenged with the design task and do not contribute any useful input for designers.

The field of analysing procedures in designing is known as design research or Design Science. The first attempts for a theorisation of Design appeared in the 1920s when emerging technologies fascinated designers and they started to see their sketches in the perspective of its purpose and not only as an expression of their creativity (Van Doesburg, 1923; Le Corbusier & Eardley, 1973). In the 1960s, the discussion arose again when Gregory published *The Design Method* in which he broke design myths and clarified that "Design is not about creativity, it is about problems" (Gregory, 1966). The idea of Design Science does not only affect the way of planning Citizen Design Science experiments, it is also relevant for evaluating the results. The idea of Design Science is to evaluate and rate design by certain criteria - a thesis which does not receive agreement of every designer. Christopher Alexander's *A Pattern language* (Alexander, 1971) can be seen as an approach to categorise urban design and make is thus comparable. His work is from our point of view a right step but nevertheless in some regards normative and based rather on impressions than on data. The question of which criteria make a city liveable is culturally different and therefore requires evidence. Design proposals by citizens can be a form of this evidence.

There are approaches which follow this philosophy. Ewing and Handy (2009) published a work which aims to measure the walkability of a city area. Imageability, enclosure, human scale, transparency and complexity are evaluated to be the five qualitative criteria which are important for making a district attractive for pedestrians. Many of these factors can be described objectively but to assess and describe them, it is necessary to refer to human individual perception of urban environments (Lynch, 1960; Tunnard & Pushkarev, 1963). Moore and Elliott (2016) pointed out in their work that city planners struggle to use participatory design methods effectively because "they neglected to collect the tacit knowledge generated through their participatory processes". Bryson et al. (2013) combined the idea of Design Science and Participatory Design in urban planning by formulating guidelines for participatory processes.

We see the human feedback as the yet missing and the crucial point for defining a well-fitting design for cities. Design Science as part of Citizen Design Science has the purpose to structure the procedure experiments and to quantify and formulate Citizen Design patterns.

The diagram in Fig. 1 summarises the emergence of Citizen Design Science and its relationship between the three pillars. Each element is essential to make this strategy successful in practice.

If there is no Citizen Science, the active designing with people will stay on a low level. Even for design issues on a neighbourhood scale, it is nowadays necessary to involve more than thousands of people since many people live in one neighbourhood of a high-density urban area.

Citizen Design Science without Citizen Design would mean the involvement of citizens in the planning process without the creative design aspect. The allure of Citizen Design is also the gaming aspect and the fascination of new technology for younger people. Not only is it a "no right or no wrong" process, but people can also express their ideas in an unanticipated way which could mean a higher motivation to participate.

Design Science methods are indispensable for Citizen Design Science. It is simply not feasible for a designer to analyse thousands of design proposals and find commonalities between all ideas. In the same way, technologies are used to provide tools for Citizen Science, they must be employed to evaluate the designs.

We want to locate Citizen Design Science in the realm of design research and take Sanders' topography of research areas in design (Sanders, 2006) as basis for that. The map consists of two dimension: The horizontal dimension represents the level of user participation in

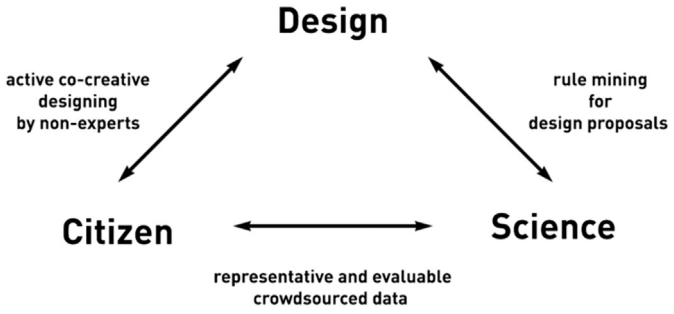


**Fig. 1.** The three parts of Citizen Design Science: Citizen Science, Citizen Design and Design Science.

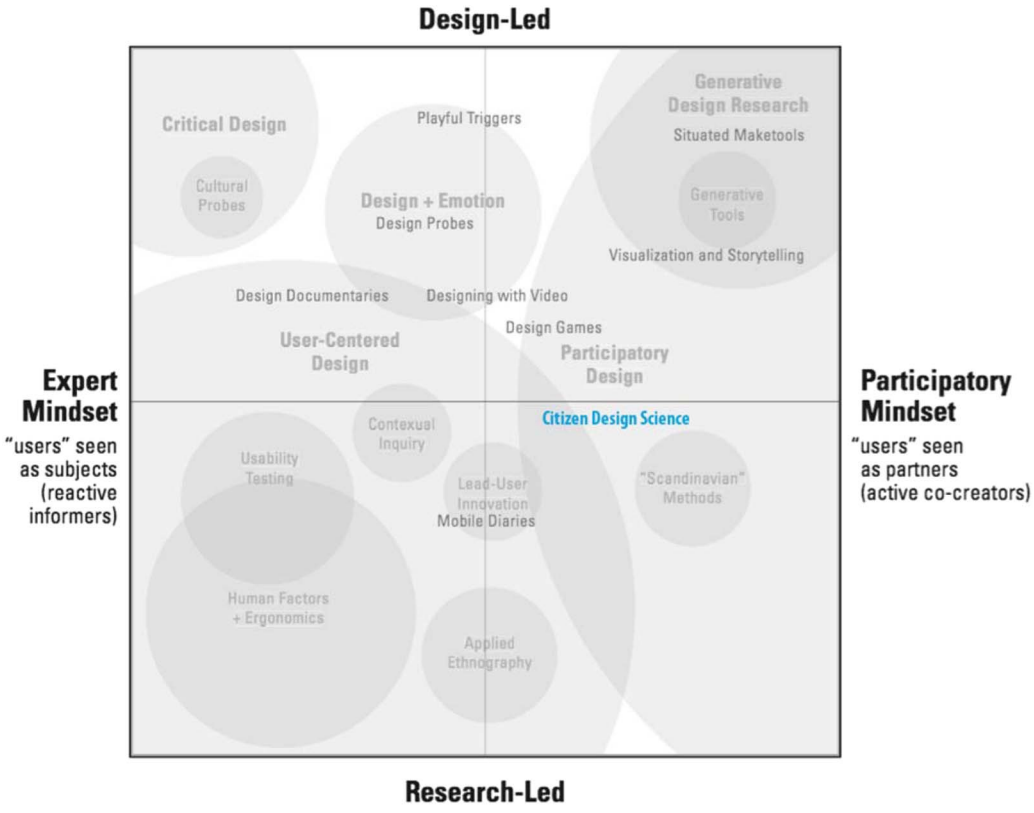


**Fig. 2.** Sanders' map of new tools and methods in Design Research (Sanders, 2008), added by Citizen Design Science.

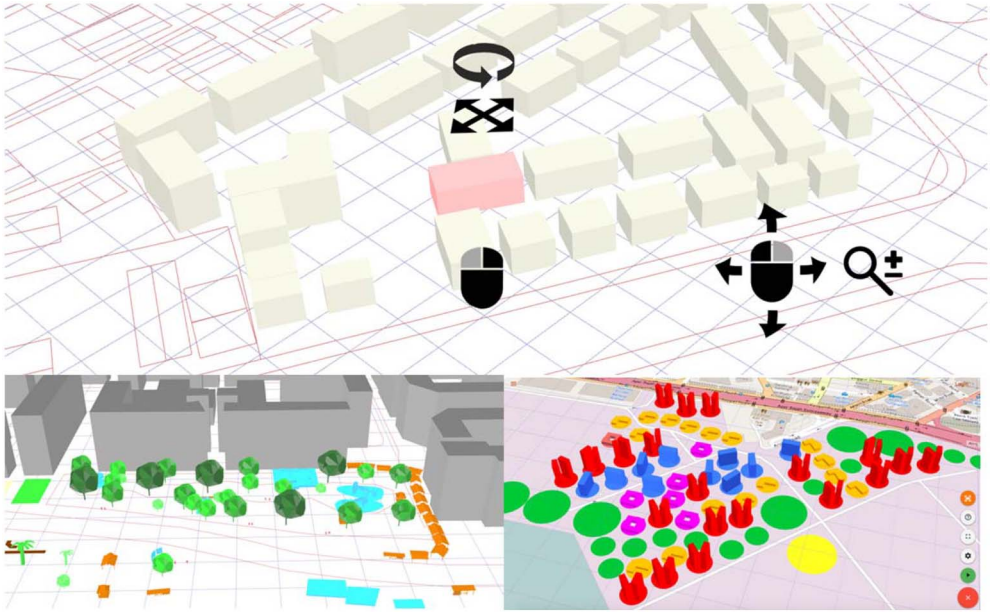

**Fig. 3.** Screenshots of the qua-kit viewer. Above: The marked red coloured object is movable in x- and y-direction, and can be rotated. By right-clicking and scrolling, the user can change his view perspective, zooming in or out. Below: Examples from scenarios on micro and macro scale. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

the design process. User-centred design processes assume that designers have the better experience in designing the object and should take the main decisions. Participatory design involves the user in the process. The user may serve as a simple idea input but can also make decisions in the process. The vertical dimension describes the origin of the design strategy. Sanders distinguishes between approaches which emerged from practice (design-led) and those which are developed from theory (research-led).

The map refers to general design research, but even if Citizen Design Science in just defined the context of urban design, it is meaningful to locate this strategy as shown in Fig. 2. The participation and empowerment of citizens in our approach is an essential point. Nevertheless, we do not propose an entire bottom-up design process. The vertical location in the map can be explained by the development of the existing methods. As shown at the end of the section, most approaches are research-led, but there are nonetheless examples of Citizen Design Science arisen from practical demand.

The strategy of Citizen Design Science might be seen critically under some aspects. While we have demonstrated until this point the opportunities of this method, we now want to answer critical questions to this approach.

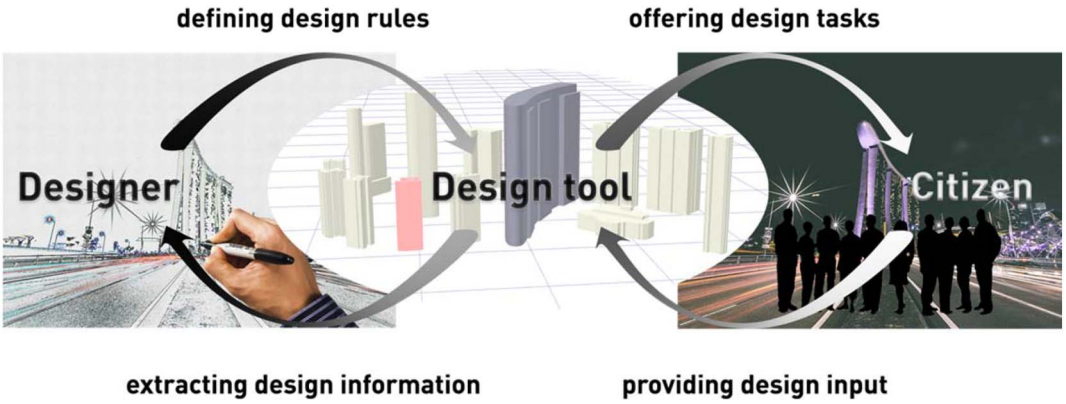


**Fig. 4.** Mingling bottom-up and top-down processes: designers and other stakeholders implement rules in the design tool and prepare a relevant design task that citizens are requested to solve. After submitting the design proposal, designers evaluate the citizens' feedback and extract useful design criteria which influence the designers' master planning.

1. *Citizens just create what they already know.*

We strongly disagree with this assumption and rely on Sanders' theory of tacit and latent user experience. This implies that citizens would not only create the urban environment in experiments in the way they know it but also enrich it with their wishes, dreams and personal demands.

2. *Citizens do not have the entire view of a city; they are just focused on optimising their neighbourhood.*

It is clear that neighbourhood interests may diverge from general interests of a municipality. White already pointed out that there are top-down and bottom-up interests (White, 1996) in a city. Residents rely for instance on the one side on good infrastructure, but a highway in the backyard is usually not an improvement for the neighbourhood. Citizen Design Science offers the chance of meeting in the middle. Municipalities can integrate their demands (like minimum number of buildings in a new redeveloping area) in the design tool and citizens manage the design task under these requirements. Another option is to take this tool as an option for bottom-up responses and adopt the neighbourhood's perspective of citizens to the top-down perspective by questioning the general direction of policies which often follows rather economical than residential interests.

3. *Oral and written consultations of citizens give more input than complicated Citizen Design Science experiments.*

We cannot prove the contrary at the moment but we assume that we will get a different kind of feedback by the citizens. The access of this knowledge may be more difficult but the benefit of the latent experience can be more valuable than any spoken or written comment.

4. *The direct dialogue between citizens and design makers is essential and not replaceable by computer technologies.*

We are aware that direct public debates with decision makers or community workshops are not exchangeable by any high-tech computer tools. We do not want to set Citizen Design Science in competition to other participatory design strategies but see it as an additional, powerful opportunity for urban planning. An approach that tackles the challenge of personal contact and computer-driven technologies, is presented by Stimmel. She suggests design thinking methods for urban planning in smart cities which encompasses a “human-centred process that comprehends the phases of empathy, creativity and rationality” (Stimmel, 2015, p.89). Carpini, Cook, and Jacobs (2004) concluded in their review of empirical literature on public deliberation, discursive participation and citizen engagement that the internet entails the opportunity to serve as a useful tool “both for studying deliberation and for increasing its use by and utility for citizens”. It is nevertheless an existing key challenges to prove the yet limited evidence demonstrating public influence and power to shape decision (Beebeejaun, 2016).

At the end of the presentation and examination of Citizen Design Science, we give some examples how this design method may look in practice.

Kevin Lynch's strategy of mental mapping can be seen as one of the first Citizen Design Science methods. Mental maps are used in behavioural geography and have become famous through Lynch's studies presented in “The Image of the City” (Lynch, 1960). The task for participants of his studies was to draw simple sketches of maps from their urban area of interaction. Lynch revealed five elements of a city which are most remarkable from the personal point-of-view perception (landmarks, nodes, paths, districts, edges). In participatory planning, this approach can help to understand important landmarks and buildings and how the environment is perceived by the locals. The already above mentioned project *block-by block* is an example of Citizen Design Science if it is applied to a representative part of residents. Citizen Design is the clue point of this project and Design Science methods are applicable since the results of the Minecraft designs are easily evaluable. *UFO* (*Urban Fabric Organisation*) will release in collaboration with the authors of the collaborative planning tool *Unlimited Cities Pro* a free application named *Unlimited Cities DIY* (www.unli-diy.org). Users can take pictures of their (urban) environment and drag elements like trees, benches and taxi stops into the picture. The Design Science aspect is contained in the evaluation method. To reveal the common content and knowledge from all different propositions, the app e.g. counts the frequencies of particular elements in each spot. Jannack, Münster, and Noennig (2016) propose in their work a design of a blueprint for a participatory creative platform. The various pieces of information about the project space are translated to a project information model. In turn, then, moderated models are developed and displayed to the respective users. The public feedback is at the end presented by way of semantic analysis to co-designers and decision makers.

## 4. Citizen Design Science in practice: the Quick Urban Analysis Kit

In the last section of this paper, we want to present an ICT tool which can be employed for Citizen Design Science experiments. The Quick Urban Analysis Kit (qua-kit) software is developed by Artem Chirkin at the Chair of Information Architecture at ETH Zurich (Chirkin & König, 2016). The visible interface of the tool is an online viewer retrievable via http://qua-kit.ethz.ch/viewer. This viewer can show 3D objects that are either movable or static. The main function of the qua-kit is that it allows the user to manipulate the position of the object, and rotate it if necessary. The objects themselves cannot be edited, which reduces the complexity of the qua-kit for the user, but

also the overall capabilities of the tool itself. Blocks also cannot be stacked; this prevents the kit from being too closely reminiscent of a Lego brick editor. The user makes modifications with the left mouse button, while the right-click changes the position of view. The scroll wheel allows the user to zoom in and out. This makes using the qua-kit with a mouse more intuitive than a touchscreen, since the latter will require additional keys for the user to manipulate objects.

This simple web application enables non-expert designers to modify given geometry layouts according to their individual preferences. The focus is on the configuration of geometries, and not on the building of infrastructure or creating new items. The final layout can be saved and submitted with optional comments on the user's design motives or further explanations.

Fig. 3 shows different applications of the tool. The upper-half of the illustration contains objects representing buildings that can be moved and rotated according to the users' preferences. The lower left simulation was used for a community workshop that targeted upgrading the open space between the building blocks. On this micro-scale scenario, the objects of interest are trees, benches and other facilities that are useful for park and open space design. The lower-right picture shows a redeveloping area and is built on a macro-scale. Citizens are requested to arrange areas with different functions (residential, commercial, park etc.) which are indicated by different colours. The submitted design proposals will reveal information from the citizens that would not have been accessed through direct questions on surveys.

The easy access is a key factor for citizen science studies. Qua-kit offers the opportunity for designing without any instructions by designers. Design tasks can be formulated in a way that they can be solved within a few minutes for participants. Galleries showing design submissions of other participants allow voting and commenting of proposals and can lead to users reflecting on their own ideas and preferences. Another important factor is the good quality of data that is collected with this tool. The submissions are not photos or real 3D models but geo data such that geographic evaluation algorithms can easily be applied without doing the stage of image recognition.

A drawback is certainly that objects cannot be directly edited. This reduces the creativity of participants but also ensures that the participants focus on the configuration of objects and do not get lost in the creation of new items.

The tool can be applied to bottom-up interactions, which would mean that citizens decide to build their preferred design solutions and discuss optionally possible variations. We propose a variation which connects the bottom-up and top-down decision-making processes. We see the citizens as non-negligible source of local knowledge but do not suggest to leave out the experience of experts. Fig. 4 shows how online design tools can embed citizens as stakeholders for the urban planning process. Designers (respectively urban planners, authorities etc.) design the tool with the given constraints which include, for instance, height restrictions or a required density. They formulate a design task for citizens that is relevant for their planning development. Citizens contribute to this task by submitting their design ideas through the online tool. The results will be evaluated and formulated as design criteria and thus are useful for the work of designers.

Suggested criteria for the qua-kit on a district level (i.e. buildings are objects) are, for instance, the Gross Plot Ratio and the connectivity and accessibility of buildings and green spaces. This information would never have been accessed in group discussions or other forms of participation and are a proof for the utility of make tools in the mass-participatory process. The configuration of buildings in combination with comments by the participants also allows for conclusions that can lead to more sophisticated criteria for design. These meta information are e.g. the importance of safety and social connection.

## 5. Conclusion

This paper describes a new strategy of urban design with the purpose to overcome the technological perspective of current urban planning methods towards a participatory planning approach. The drawbacks of the participatory planning that we focus on are low representation and the cost-intensive process of face-to-face workshops. This work also addresses the missing option for creativity of many participation tools.

Online participation tools create the opportunity for a large number of people to simultaneously provide direct feedback without high expenditure. Active design in workshops with residents is the most common approach to overcome the limited creativity of participatory planning tools. Methods which combine these two solutions is what we designate as Citizen Design Science.

Harnessing the knowledge of the crowd is a typical *Citizen Science* method. The active designing in the co-design approach is what we call *Citizen Design*. The combination of these two fields require techniques from a third research area, namely *Design Science*. Since the direct communication with the designers is replaced by anonymous submissions of design proposals, it is necessary to access the tacit knowledge of people in a different way. Design Science is therefore obligatory to identify design criteria which are essential for designers in the specific use case.

*Qua-kit* is presented as an ICT tool which can be used for Citizen Design Science experiments. The tool allows crowd-creative participation on different urban scales, by arranging geometries in given scenarios.

The upcoming challenges in this research area refer to various disciplines. To build realistic case studies for research, it is important to promote the opportunities of Citizen Design Science to planners and authorities. Directly linked to this issue is the question of how the output of the design exercises can be used and communicated for other stakeholders and how useful design proposals from citizens are. Next to these challenges in urban governance, a sociological interesting question is in what age the dominant part of the participants is. If younger people are overrepresented, it can be discussed how ideas of online design tools can be combined with conventional participation methods which are usually used by elderly and non-technophiles.

Future research publications will also refer to the question of an appropriate formulation of the design exercises that is given to non-experts. This is related to local design aspects as well as knowledge management. It will also be on the agenda to have an overview of existing online design tools and describe which of them are the most appropriate for which design question and where the limits of these tools and Citizen Design Science in general are.

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